國立成功大學

110學年度碩士班招生考試試題

編　號：66

系　所：機械工程學系

科　目：熱力學

日　期：0202

節　次：第 2 節

備　註：可使用計算機

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1. A piston assembly in a car contains $2 \cdot 10^{-4} m^3$ of air at 90 kPa and 20°C. The air inside is compressed in a polytropic process with n=1.25 ($P \cdot v^n$=constant where P is pressure and v is specific volume) to a final volume six times smaller. Determine the final pressure, temperature, and the heat transfer for the process. The gas constant of air R is 0.287 kJ/kg·K.(25%)

2. A 2-m^3 storage tank contains 95% liquid and 5% vapor by volume of liquified natural gas (LNG) at 160 K, as shown in Figure. 1. It may be assumed that LNG has the same properties as pure methane. The saturated vapor at 160 K flows to the heater from the tank until all the liquid in the storage tank is gone. Then the superheated vapor finally leaves the heater at 300 K. Calculate the heat transfer to the tank Q_{tank} and heat transfer to the heater Q_{heater} assuming that flow in the heater is steady and the process works at a constant pressure. (25%)

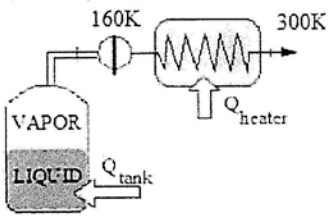

Figure. 1

Properties of methane

Saturated Methane

		Specific Volume, m^3/kg			Internal Energy, kJ/kg			Enthalpy, kJ/kg		
Temp.	P (kPa)	v_f	v_{fg}	v_g	u_f	u_{fg}	u_g	h_f	h_{fg}	h_g
145	823.7	0.002719	0.07445	0.07717	−165.97	368.06	202.09	−163.73	429.38	265.66
150	1040.5	0.002794	0.05839	0.06118	−146.65	351.53	204.88	−143.74	412.29	268.54
155	1295.6	0.002877	0.04605	0.04892	−126.82	333.61	206.79	−123.09	393.27	270.18
160	1592.8	0.002974	0.03638	0.03936	−106.35	314.01	207.66	−101.61	371.96	270.35
165	1935.9	0.003086	0.02868	0.03177	−85.06	292.30	207.24	−79.08	347.82	268.74
170	2329.3	0.003222	0.02241	0.02563	−62.67	267.81	205.14	−55.17	320.02	264.85
175	2777.6	0.003393	0.01718	0.02058	−38.75	239.47	200.72	−29.33	287.20	257.87
180	3286.4	0.003623	0.01266	0.01629	−12.43	205.16	192.73	−0.53	246.77	246.25

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Superheated Methane

Temp. (K)	v (m^3/kg)	u (kJ/kg)	h (kJ/kg)	s (kJ/kg-K)	v (m^3/kg)	u (kJ/kg)	h (kJ/kg)	s (kJ/kg-K)
	1500 kPa (158.52 K)				2000 kPa (165.86 K)			
Sat.	0.04196	207.53	270.47	8.6215	0.03062	207.01	268.25	8.4975
250	0.08220	375.70	499.00	9.7730	0.06059	370.67	491.84	9.6036
275	0.09171	418.65	556.21	9.9911	0.06796	414.40	550.31	9.8266
300	0.10103	462.27	613.82	10.1916	0.07513	458.59	608.85	10.0303
325	0.11022	507.04	672.37	10.3790	0.08216	503.80	668.12	10.2200
350	0.11931	553.30	732.26	10.5565	0.08909	550.40	728.58	10.3992
375	0.12832	601.30	793.78	10.7263	0.09594	598.69	790.57	10.5703
400	0.13728	651.24	857.16	10.8899	0.10274	648.87	854.34	10.7349

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3. Air enters the compressor of a Brayton cycle at 100 kPa, 300 K, with a volumetric flow rate 5 m^3/s . In the cycle, air is assumed to behave as an ideal gas. The compressor pressure ratio is 10 and its isentropic efficiency is 85 %. At the inlet of the gas turbine the pressure of air is 950 kPa, and the temperature is 1400K. The turbine has an isentropic efficiency is 88 % and the exit pressure is 100 kPa. In addition, the temperature rise that would be brought by combustion is assumed to be accomplished by a heat transfer from an external source. (a) Sketch the T-s diagram of the cycle. (6%)
Calculate (b) the specific enthalpy, in kJ/kg , at the exit the compressor, (c) the net power of the cycle, in kW , and (d) the change of specific entropy, in $kJ/kg \cdot K$, between the exit and the inlet of the turbine. (24%)

4. From the data that follow, estimate $h_g - h_f$, in kJ/kg , for benzene (苯) at 340 K. At this temperature, $p_{sat} = 66.15\ kPa$, $v_f = 0.0012\ m^3/kg$, $v_g = 0.5332\ m^3/kg$. In addition, at 350 K, $p_{sat} = 91.62\ kPa$. The vapor-pressure curve can be represented by the two-constant equation

$$\ln(p_{sat}) = A - B/T,$$

where A and B are constant. (20%)

Ideal gas properties for Air

T(K), h and u(kJ/kg), s° (kJ/kg · K)											
				when $\Delta s = 0^1$						when $\Delta s = 0$	
T	h	u	s°	p_r	v_r	T	h	u	s°	p_r	v_r
200	199.97	142.56	1.29559	0.3363	1707.	450	451.80	322.62	2.11161	5.775	223.6
210	209.97	149.69	1.34444	0.3987	1512.	460	462.02	329.97	2.13407	6.245	211.4
220	219.97	156.82	1.39105	0.4690	1346.	470	472.24	337.32	2.15604	6.742	200.1
230	230.02	164.00	1.43557	0.5477	1205.	480	482.49	344.70	2.17760	7.268	189.5
240	240.02	171.13	1.47824	0.6355	1084.	490	492.74	352.08	2.19876	7.824	179.7
250	250.05	178.28	1.51917	0.7329	979.	500	503.02	359.49	2.21952	8.411	170.6
260	260.09	185.45	1.55848	0.8405	887.8	510	513.32	366.92	2.23993	9.031	162.1
270	270.11	192.60	1.59634	0.9590	808.0	520	523.63	374.36	2.25997	9.684	154.1
280	280.13	199.75	1.63279	1.0889	738.0	530	533.98	381.84	2.27967	10.37	146.7
285	285.14	203.33	1.65055	1.1584	706.1	540	544.35	389.34	2.29906	11.10	139.7
290	290.16	206.91	1.66802	1.2311	676.1	550	554.74	396.86	2.31809	11.86	133.1
295	295.17	210.49	1.68515	1.3068	647.9	560	565.17	404.42	2.33685	12.66	127.0
300	300.19	214.07	1.70203	1.3860	621.2	570	575.59	411.97	2.35531	13.50	121.2
305	305.22	217.67	1.71865	1.4686	596.0	580	586.04	419.55	2.37348	14.38	115.7
310	310.24	221.25	1.73498	1.5546	572.3	590	596.52	427.15	2.39140	15.31	110.6
315	315.27	224.85	1.75106	1.6442	549.8	600	607.02	434.78	2.40902	16.28	105.8
320	320.29	228.42	1.76690	1.7375	528.6	610	617.53	442.42	2.42644	17.30	101.2
325	325.31	232.02	1.78249	1.8345	508.4	620	628.07	450.09	2.44356	18.36	96.92
330	330.34	235.61	1.79783	1.9352	489.4	630	638.63	457.78	2.46048	19.84	92.84
340	340.42	242.82	1.82790	2.149	454.1	640	649.22	465.50	2.47716	20.64	88.99

Ideal gas properties for Air (Continued)

T(K), h and u(kJ/kg), s° (kJ/kg · K)

T	h	u	s°	when $\Delta s = 0$[1] p_r	v_r	T	h	u	s°	when $\Delta s = 0$ p_r	v_r
750	767.29	551.99	2.64737	37.35	57.63	1300	1395.97	1022.82	3.27345	330.9	11.275
760	778.18	560.01	2.66176	39.27	55.54	1320	1419.76	1040.88	3.29160	352.5	10.747
770	789.11	568.07	2.67595	41.31	53.39	1340	1443.60	1058.94	3.30959	375.3	10.247
780	800.03	576.12	2.69013	43.35	51.64	1360	1467.49	1077.10	3.32724	399.1	9.780
790	810.99	584.21	2.70400	45.55	49.86	1380	1491.44	1095.26	3.34474	424.2	9.337
800	821.95	592.30	2.71787	47.75	48.08	1400	1515.42	1113.52	3.36200	450.5	8.919
820	843.98	608.59	2.74504	52.59	44.84	1420	1539.44	1131.77	3.37901	478.0	8.526
840	866.08	624.95	2.77170	57.60	41.85	1440	1563.51	1150.13	3.39586	506.9	8.153
860	888.27	641.40	2.79783	63.09	39.12	1460	1587.63	1168.49	3.41247	537.1	7.801
880	910.56	657.95	2.82344	68.98	36.61	1480	1611.79	1186.95	3.42892	568.8	7.468
900	932.93	674.58	2.84856	75.29	34.31	1500	1635.97	1205.41	3.44516	601.9	7.152
920	955.38	691.28	2.87324	82.05	32.18	1520	1660.23	1223.87	3.46120	636.5	6.854
940	977.92	708.08	2.89748	89.28	30.22	1540	1684.51	1242.43	3.47712	672.8	6.569
960	1000.55	725.02	2.92128	97.00	28.40	1560	1708.82	1260.99	3.49276	710.5	6.301
980	1023.25	741.98	2.94468	105.2	26.73	1580	1733.17	1279.65	3.50829	750.0	6.046
1000	1046.04	758.94	2.96770	114.0	25.17	1600	1757.57	1298.30	3.52364	791.2	5.804
1020	1068.89	776.10	2.99034	123.4	23.72	1620	1782.00	1316.96	3.53879	834.1	5.574
1040	1091.85	793.36	3.01260	133.3	22.39	1640	1806.46	1335.72	3.55381	878.9	5.355
1060	1114.86	810.62	3.03449	143.9	21.14	1660	1830.96	1354.48	3.56867	925.6	5.147
1080	1137.89	827.88	3.05608	155.2	19.98	1680	1855.50	1373.24	3.58335	974.2	4.949
1100	1161.07	845.33	3.07732	167.1	18.896	1700	1880.1	1392.7	3.5979	1025	4.761
1120	1184.28	862.79	3.09825	179.7	17.886	1750	1941.6	1439.8	3.6336	1161	4.328
1140	1207.57	880.35	3.11883	193.1	16.946	1800	2003.3	1487.2	3.6684	1310	3.944
1160	1230.92	897.91	3.13916	207.2	16.064	1850	2065.3	1534.9	3.7023	1475	3.601
1180	1254.34	915.57	3.15916	222.2	15.241	1900	2127.4	1582.6	3.7354	1655	3.295
1200	1277.79	933.33	3.17888	238.0	14.470	1950	2189.7	1630.6	3.7677	1852	3.022
1220	1301.31	951.09	3.19834	254.7	13.747	2000	2252.1	1678.7	3.7994	2068	2.776
1240	1324.93	968.95	3.21751	272.3	13.069	2050	2314.6	1726.8	3.8303	2303	2.555
1260	1348.55	986.90	3.23638	290.8	12.435	2100	2377.4	1775.3	3.8605	2559	2.356
1280	1372.24	1004.76	3.25510	310.4	11.835	2150	2440.3	1823.8	3.8901	2837	2.175